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AUTHOR(S):

KUMA, TOKIO

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EXPERIMENTAL STUDIES ON CONSTRICTIVE PERICARDITIS: THE PRESSURE PULSE TRACINGS IN THE RIGHT HEART

by

Tokio Kuma

From the 2nd Surgical Division, Kyoto University Medical School
(Director: Prof. Dr. Yasumasa Aoyagi)
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Although there are many papers on constrictive pericarditis, wide discrepancies are found as to where and how much of the pericardium should be removed from the constricted heart in the surgical treatment of constrictive pericarditis.

Parson & Holman (1955), Isaacs & Haller (1952) tried to clarify this, for the most part, by experimental studies.

Hansen et al. have reported that the pressure curves in the atrium and ventricle are pathognomonic hemodynamically in chronic constrictive pericarditis. They also emphasized that the appearance of certain ventricular curves, especially the early diastolic dip, might be indicative for the estimation of the condition of the myocardium.

These problems are highly important in the surgical treatment, although few reports have been published on the problems of myocardial failure which is always accompanied, more or less, by constrictive pericarditis.

The following experimental studies were performed for the purpose of clarifying these problems.

MATERIALS AND METHODS

Using mongrel male and female dogs, intravenous thiopental sodium (Ravonal) anesthesia and ether anesthesia, or in some cases intraabdominal urethan anesthesia combined with subcutaneous morphine injections and endotracheal positive pressure respiration, the heart was exposed through a left or right anterolateral intercostal thoracotomy. Polyvinylformal sponges, which have been used by Nagaishi et al. of the Department of Surgery, Tuberculosis Research Institute, Kyoto University, as the plombing material in living bodies, were inserted into the pericardial cavity employing either Isaacs' method of segmental constriction or that of direct suture of the sponge to the myocardium. In some cases irritant chemical substances (Cemedine C-No 321) were used in combination with these sponges. By these methods diffuse and segmental constriction of the heart were produced.

Right heart catheterization and pressure recordings were performed under the anesthesia as above, employing conventional methods and in a few cases pressure recordings were taken by direct heart punctures under unanesthetized condition, in a face down position, to prevent any increase in heart rate.

The zeropoint was set at the junction of the jugular and subclavicular vein.

E. C. G. tracings were made using intravenous injection needles inserted into the

subcutaneous tissues of the limbs as leads.

Respiration curves were recorded by leading the intratracheal pressure to a rubber membrane manometer, and phonocardiograms from the most suitable part on the left sternal border.

These recordings were done simultaneously with a multielement magnetic oscillograph.

The pressure recordings were an essential part of this study. They were made by means of an electromanometer constructed by the author.

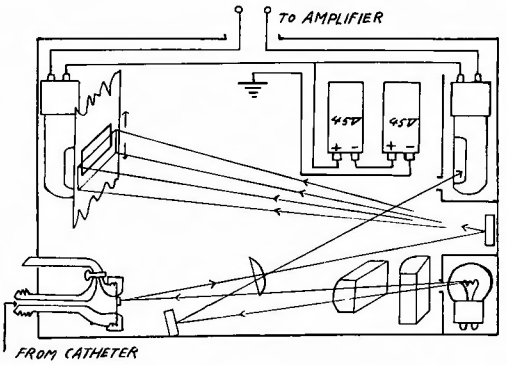


Fig. 1
Scheme of the photo-electric transducer.

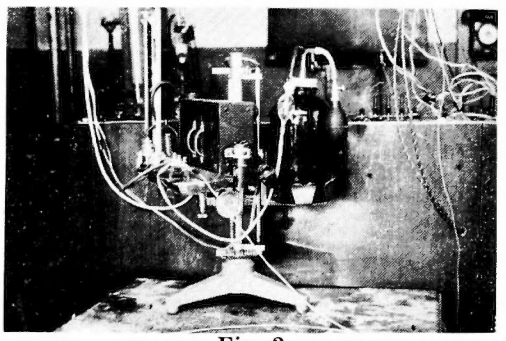


Fig. 2
Outside view of the pressure-electric transducer constructed by the author.

In the beginning of this study, there has not been a commercially available electromanometer in this country. For this reason, the author constructed a photoelectric manometer by reconstructing the direct writing earpiece type oximeter.

This oximeter has been constructed and used clinically by the author previous to this study.

A pressure-electric transducer was easily constructed by combining an optical membrane manometer and photoelectric tubes, as the oximeter was a phototube type connected to a direct-coupled three stages amplifier (Fig. 1, 2).

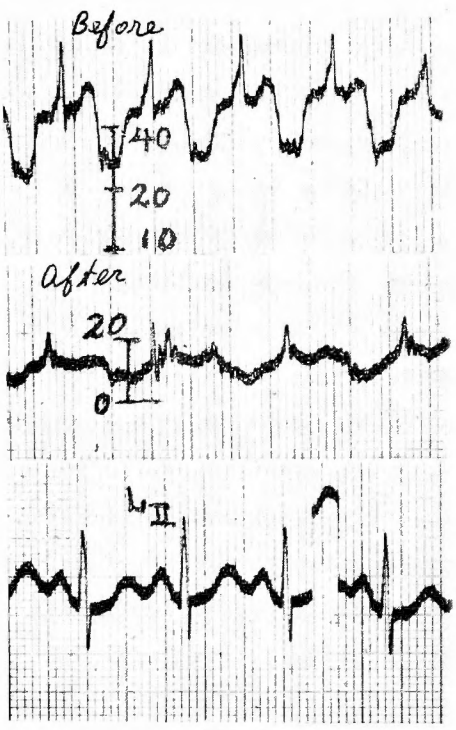
The diaphragm of the optical membrane manometer is made of a piece of phosphor-bronze 6 mm in diameter, 0.1mm thickness. The compliance of this manometer is calculated roughly as 0.05 mm^3 per 100 mm Hg using the deflection of the light column. The natural frequency of this manometer system is about 30 cycles per second in combination with a F. 9 cardiac catheter.

The hysteresis phenomen is negligible. The output of the transducer is 1mV per 10mm Hg in ordinary use.

These data show that the pressure recording system is adequate for this study.

The sensibility was also adequate for this study, so that a photomultiplier was not used. If it were necessary, it is, therefore, very easy to use this transducer as a direct writing manometer by connecting it to a direct writing recorder in which a direct-coupled amplifier is built in. In our clinic, this transducer has been used in the same method reported above in an operation on the heart (Fig. 3 A, B, C).

In most parts of the study, the output of the transducer was amplified with the same amplifier as the oximeter (Fig. 4). The simultaneous pressure curves and



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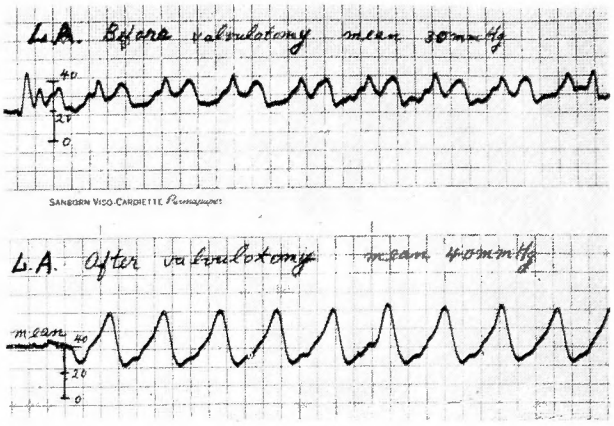

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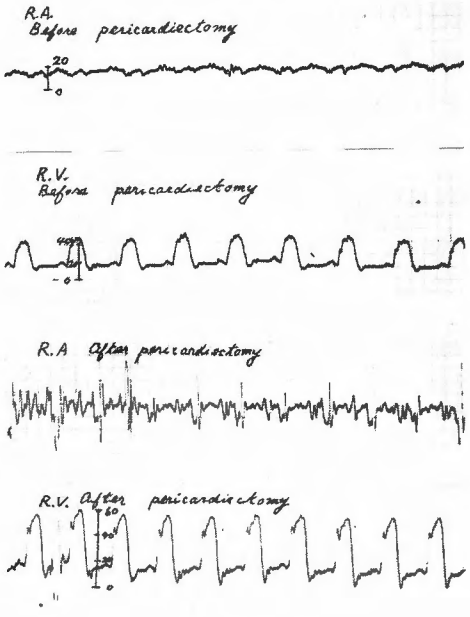


C

Fig. 3 A

Clinical use of this manometer with its connection to heated stylus recorder.

A. The pressure tracings in the left atrium obtained before and after valvulotomy, from a patient (25 years of age, male) with mitral stenosis.

B. From a patient (32 years of age, female) who was cured, although a strong regurgitant jet occured as the result of valvulotomy.

C. Obtained from patient (22 years of age, male) with constrictive pericarditis. Before pericardiectomy, the early diastolic dip and M or W contour of the right atrial pressure tracings were vague. After pericardiectomy and epicardiolysis of both ventricles the ventricular systole became vigorous and an early diastoic dip became conspicuous, although the atrial pressure tracings involved many artefacts.

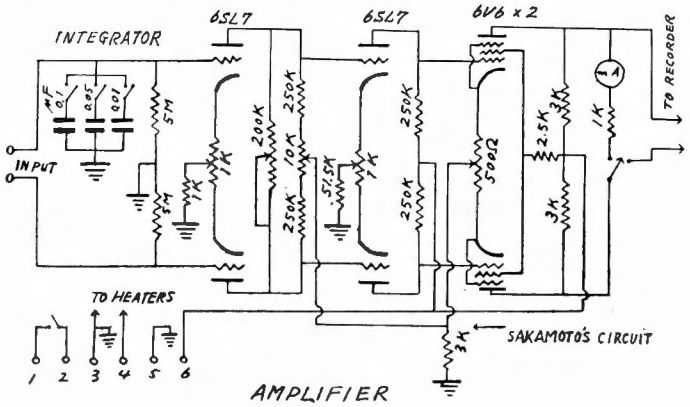
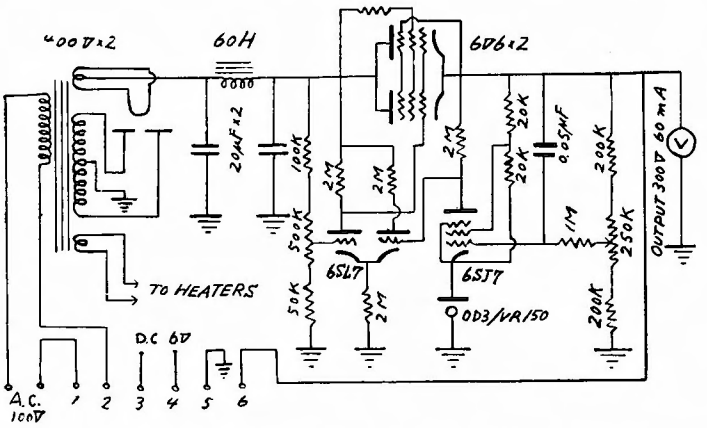


Fig. 4
Circuit diagrams of the amplifier (A) and its high tension supply (B)



STABILIZED HIGH TENSION SUPLY

(B). As a low tension supply, a 6 volts battery was used.

other recordings were obtained by a magnetic oscillograph.

A mean value was obtained by means of electric integration, and by the use of a direct writing recorder, by means of mechanical integration.

RESULT

CONTROL DATA

The average values obtained by right heart catheterization in normal dogs are illustrated in Table 1. These values are similar to that of ISAACS et al. which were measured under an unanesthetized condition, although the author measured them under general anesthesia. Normal curves are illustrated in Fig. 5.

In Fig. 6, various forms of the tracings obtained from the right atrium are shown. A typical form, in which a, c, x, v and y waves are distinguishable is not frquently optained.

Occasionally, a right ventricular curve was similar to the elevated end-diastolic pressure curve. However, simultaneous respiration and pressure curves illustrated that variation of the intrathoracic pressure made the ventricular curve pathologic (Fig. 7).

Early diastolic dips were also often observed. Observing the amplitude, the duration of the dips and especially the level of the diastolic plateau, these curves were found to differ from pathologic curves. Some of these dips were artefacts which perhaps produced by close contact to the endocardium of the vetricle by the tip of the catheter.

In cases with symptoms of constrictive pericarditis; namely, ascites, hepatomegaly, edema, hydrothorax, dyspnea and etc., general anesthesia and prolonged catheterization in a supine position were intolerable. Moreover, the silhouette of a catheter in the heart under fluoroscopic control was barely visible, and the atrial and ventricular cavity were highly constricted and narrowed. Even with excellent technique in performing the cardiac catheterization, many of them died during or after these procedures.

1) CONSTRICTION OF THE RIGHT SIDE OF THE HEART

Table 1. Averaged values obtained by right heart catheterization of 20 normal dogs.

	PULMONARY CAPILLARY PRESSURE (mmHg)	PULMONARY ARTERIAL PRESSURE (mmHg)	RIGHT VENTRICULAR PRESSURE (mmHg)	RIGHT ATRIAL PRESSURE (mmHg)
MEAN VALUE	4.67	15.7	10.7	1.07
AT EXPIRATION		27.5/8.8	28.5/2	
AT INSPIRATION		25.5/5.9	27/−0.5	

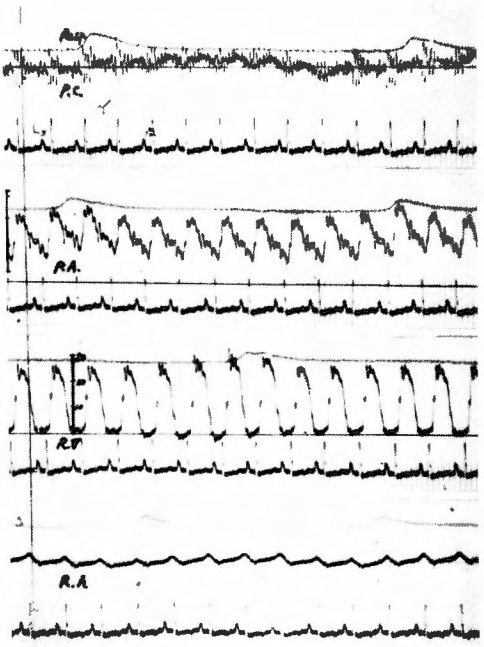


Fig. 5
Normal curves obtained by right heart catheterization without a damper.

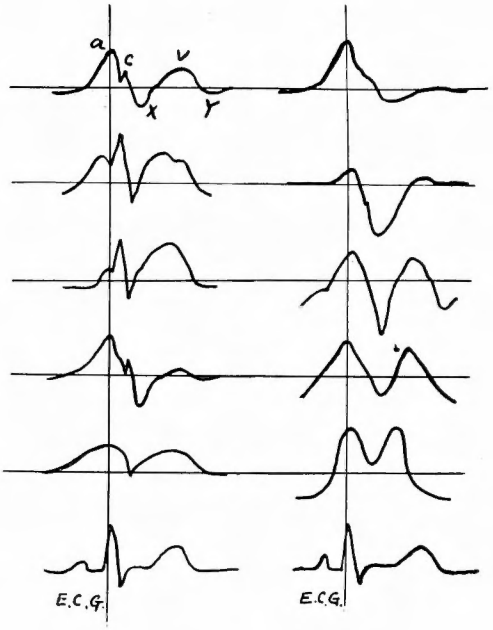


Fig. 6
Various forms obtained from the right atrium of normal dogs.

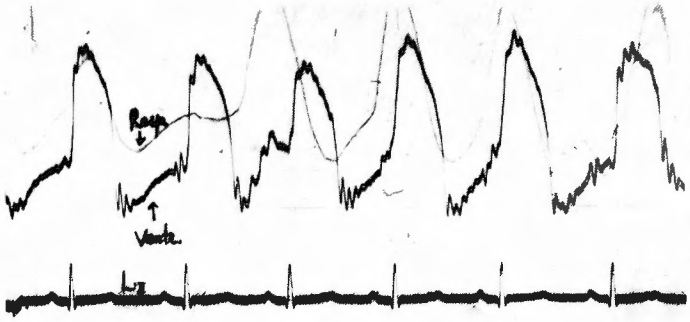


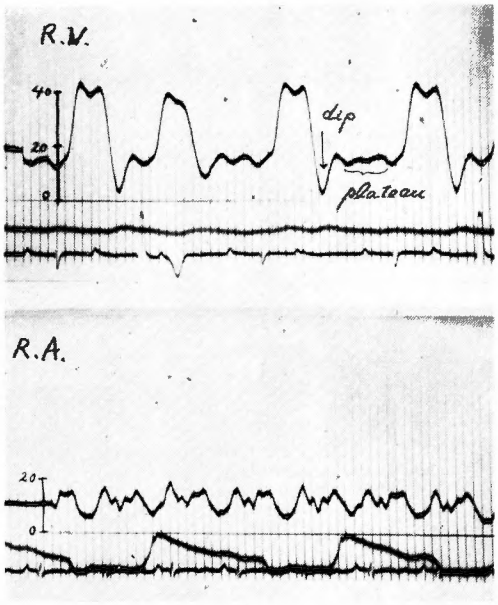
Fig. 7
The endo-diastolic pressure elevation was found to be caused by respiration.

The right side of the heart was constricted in 29 dogs and the symptoms of systemic venous congestion developed successfully in 12 dogs. Some of the following symptoms of systemic venous congestion, e. g. ascites, peripheral edema, hepatomegaly, hydrothorax, dyspnea, orthopnea, developed gradually 7 days or more after the inserting of the sponges into the pericardial cavity.

The cases in which dyspnea and orthopnea developed owing to hydrothorax, hepatomegaly and a great deal of ascites, died in a short while without repeated removal of pleural and peritoneal effusion.

In some cases with slight constrictions, edema and ascites, which developed about a week after surgery, disappeared shortly thereafter, and in some, appearance and subsidence of the symptoms were repeated.

In almost all cases manifesting these symptoms, the pressure tracings from the right atrium and ventricle were characteristic; namely, first, a high mean pressure, a M or W contour and a large amplitude in the right atrial pressure tracing, second,



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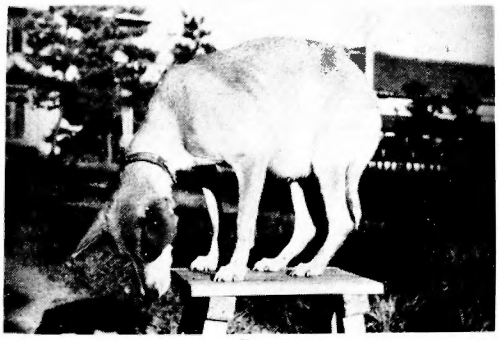

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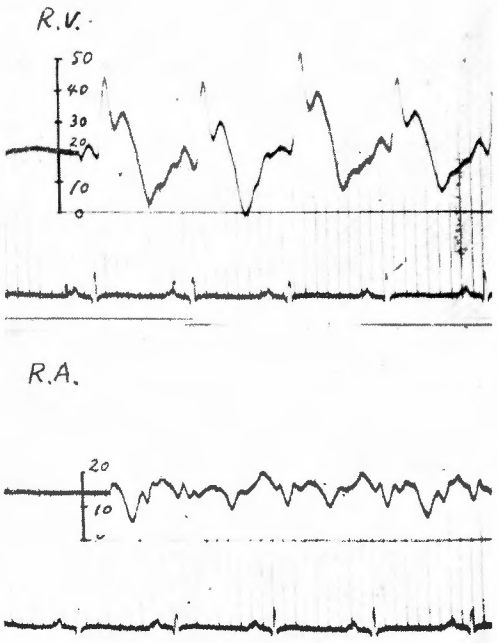

C

Fig. 8

The pressure tracings from dogs with costriction of the right side, and a photograph.

A. From dog No. 110, 57 days afer operation.

B. From dog No. 112, 25 days after.

C. photograph (15 days after) of dog No. 112, in which massive ascites and peripheral edema developed.

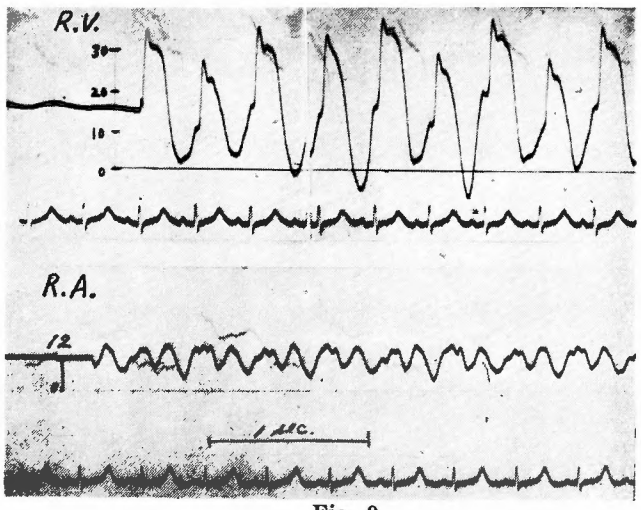

Fig. 9

From dog No. 49 with constriction of the right side, 8 days after.

an early diastolic dip followed by a rapid rise of the right ventricular diastolic pressure to form a plateau, and a ratio of the right ventricular diastolic to systolic pressure greater than one fourth (Fig. 8).

The diastolic plateau was not so distinct in many cases, since the heart rate was higher than 140 per minute under general anesthesia (Fig. 9, 10). This configuration may be adequately representated by the elevated end-diastolic pressure curve rather than by the plateau.

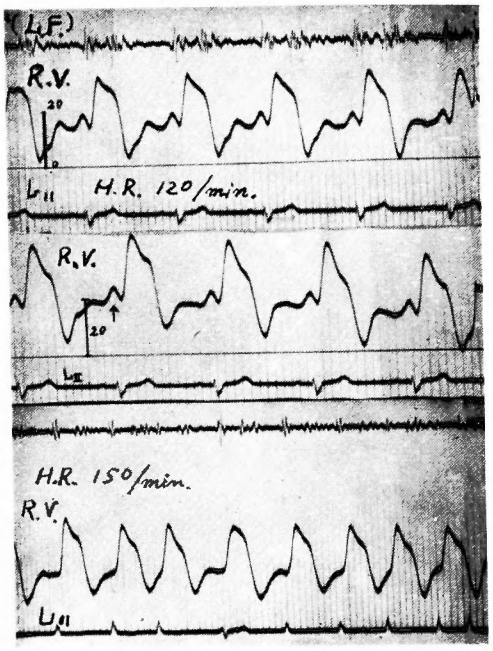

Fig. 10
Simultaneous sound and pressure tracings from dog No. 141 were obtained by right venricular puncture in a face down position in an unanesthetized condition. During the pressure recording heart rate increased from 120 to 150, the diastolic plateau became vague. A arrow mark indicates the wave caused by contraction of the left atrium, 13 days after.

By decreasing the heart rate, however, vague plateaus were found to become distinct. The case in which the plateau is not distinct was considered to be near the limit of the ability to which cardiac output can be increased by regulating the heart rate.

On the other hand, it is considered to be likely that the ventricular filling pressure can be decreased as the result of increasing the heart rate, and therefore, the diastolic plateau may be more vague.

2) CONSTRICTION OF THE LEFT SIDE OF THE HEART

The left side of the heart was constricted in 17 dogs. In the cases which were highly constricted in the left heart, heavy dyspnea appeared and râles were audible. However, catheterization was not performed in these cases, since all of them died within about the first week after the inserting of the sponges. In one of the 17 dogs, pulmonary congestion was found at autopsy. The surviving cases showed

Table. 2. Results from dog No. 24 with constriction of the left ventricle which lived for 475 days.

AFER OPERATION	7.5 MONTHS	10 MONTHS	12 MONTHS
BODY WEIGHT (kg)	13.2	12.2	10.7
PULSE RATE (PER MINUTH)	136	168	143
PULMONARY CAPILLARY MEAN PRESSURE (mmHg)	3	10	9
PULMONARY ARTERIAL PRESSURE (mmHg)	30/10	30/13	20/8.5
PULMONARY ARTERIAL MEAN PRESSURE (mmHg)	15	21	13
RIGHT VENTRICULAR PRESSURE (mmHg)	30/2	40/−2	20/−1
RIGHT ATRIAL MEAN PRESSURE (mmHg)	6	−2	−1

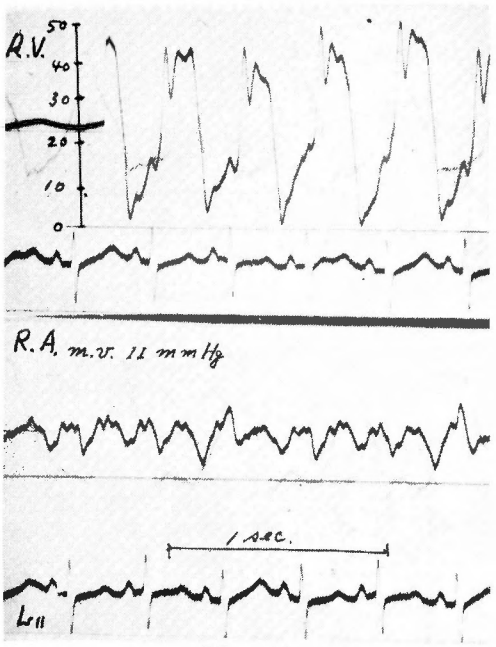

Fig. 11
From dog No. 55 with constriction of the whole heart, 7 days after. Heart rate is about 180, so that the diastolic plateau is vague.

only a slightly elevated pulmonary capillary and arterial pressure. Therefore, the curves from the right atrium and ventricle were almost normal.

The result of right heart catheterization in the case,which survived for 475 days without any symptoms and died without any known cause, is shown in Table 2.

The constriction of the left side alone of the heart caused the least number of the symptoms of heart failure.

3) CONSTRICTION OF THE WHOLE HEART

In 19 of 38 dogs with constriction of the whole heart, the symptoms developed gradually or rapidly. In all of the long surviving cases, the symptoms of left heart failure were latent, and that of right heart failure were predominant. None of the cases, which showed the symptoms of pulmonary congestion in addition to the symptoms of right heart failure, were seen.

The pulmonary capillary arterial pressure were slightly elevated. The curves from the right atrium and ventricle were all similar to the cases with constriction of the right heart (Fig. 11).

Most cases with constriction of the right or whole heart which showed similar curves to these immediately after operation, died a few hours or days after operation owing to a heart tamponade, namely, a restricted cardiac output. In 4 of these cases which died within 5 days, pulmonary congestion was found at autopsy.

In the cases with predominant symptoms of right heart failure, during the catheterization, the phenomen was occaisionally experienced, that right ventricular systolic pressure suddenly doubled or tripled for some time, without any known cause, and then droped gradually to almost the same value as before the elevation (Fig.12). In these cases the pulmonary capillary and arterial pressure could not be measured during this phenomen. This phenomen is likely to be due to a temporal increase of the pulmonary artery or capillary resistance as the result of nervous reflexes from the ventricular wall to the pulmonary vessels. The author considered that such nervous reflexes might be heightened in the cases with constrictive pericarditis. The catheterization, therefore, should be done taking into consideration this phenomen.

4) MYOCARDIAL FIBROSIS OF THE RIGHT HEART

Among the surviving cases in which the right coronary artery was ligated,

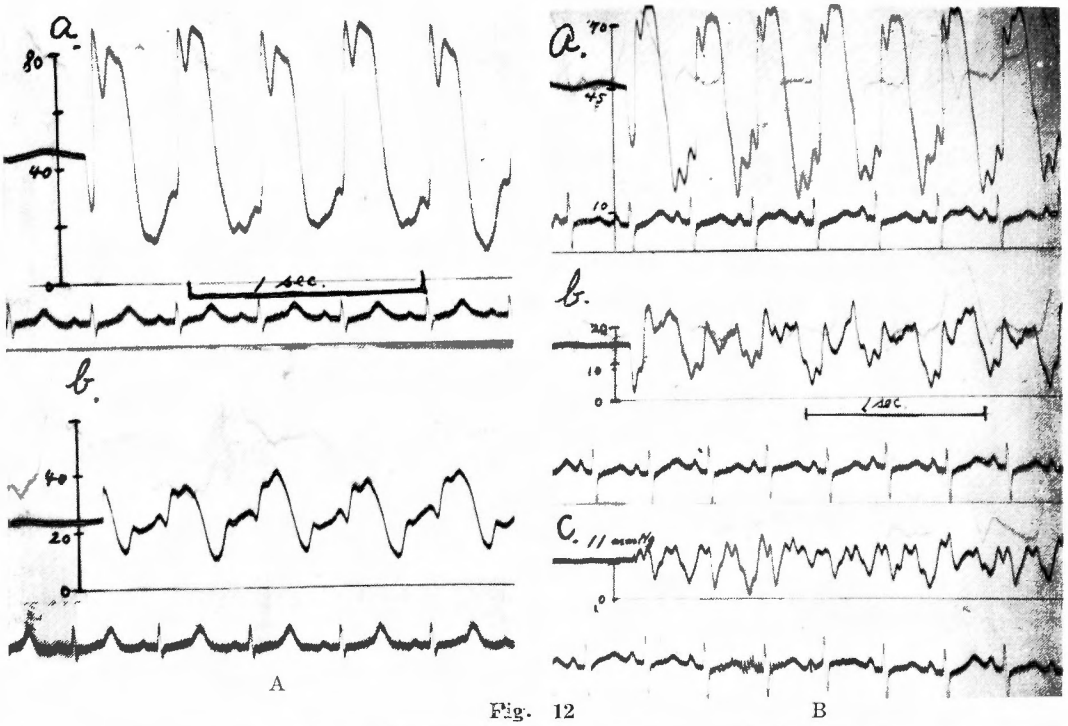

Fig. 12

The ventricular systolic pressure tripled in A. and doubled in B. suddenly, without any presumable inducement, during the pressure recording.

A. was recorded after recording of Fig. 9,
A-b. : the ventricular curve few minutes after a.,
B., after recording of Fig. 11.
B-b. : the right atrial curve immediately after a.,
B-c. : the atrial curve few minutes after b.

some developed myocardial fibrosis in small areas, and in the other cases most of the area of the right ventricular wall was involved. Even in the latter, the configuration of the right ventricular curve was the same as in constrictive pericarditis, although the symptoms of right heart failure were latent (Fig. 13). Following the ligation of the right coronary artery, the right venricular wall became cyanotic and was inflated during each systolic stage.

Theses cases demonstrate the fact that, first, the dog is free from any symptoms by the contractibility of the septum and its proximal myocardium and is capable of relatively normal function without the aid of the free ventricular wall, and second, even in other cardiac diseases except constrictive pericarditis, characteristic patterns may be obtained, as a few clinical cases which were reported by other authors, e. g. myocardial fibrosis, idiopathic constrictive endocarditis and right heart failure in other forms of cardiac disease.

5) PHONOCARDIOGRAM

In some cases, simultaneous sound and pressure curves were recorded of the right ventricle. A similar early diastolic sound as in clinical cases, namely the third heart sound was recorded, and coincided with the nadir of the typical diastolic dip

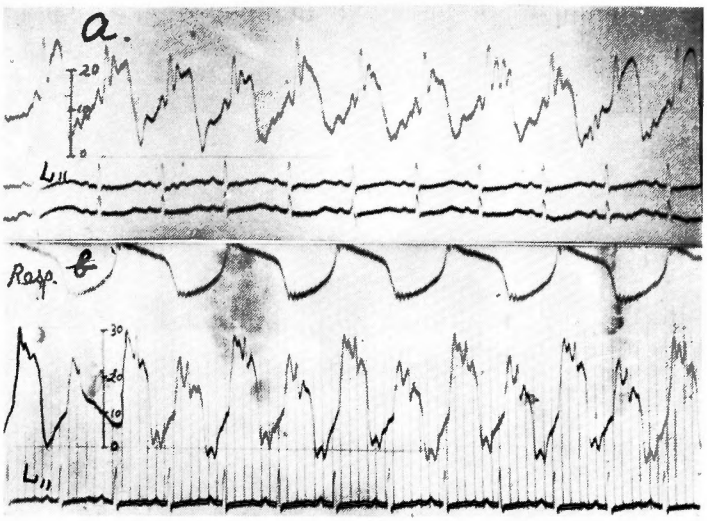

Fig. 13

a : Obtained immediately after ligation of the right coronary artery.

b : Obtained 95 days after ligation with and without a damper. These curves are similar to the cases with constrictions of the heart.

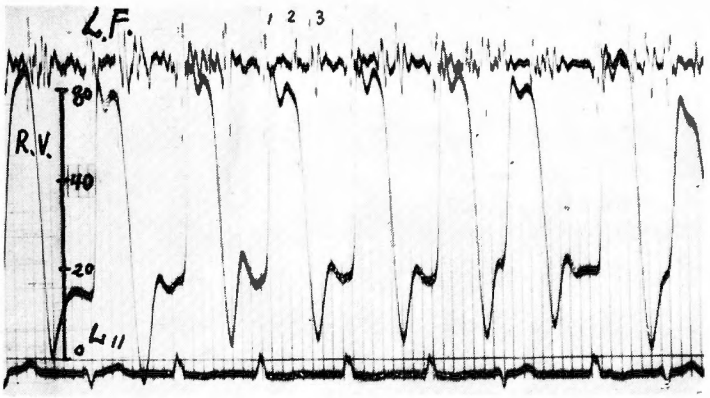

Fig. 14

From the same dog as Fig. 10, the early diastolic sound coincided with the nadir of the early diastolic dip. In this case, the ventricular systolic pressure roughly tripled during the pressure recording.

(Fig. 14). This sound was distinguished by its frequency from the inaudible third heart sound which is occasionally recorded in normal dogs.

In some cases with relatively light symptoms, the high frequency systolic sound was recorded with no typical early diastalic dip and sound.

DISCUSSION

CURVES FROM THE RIGHT ATRIUM

In normal dogs, typical atrial pressure curves were not obtained frequently.

In normal dogs with no typical atrial pressure curve, the curve became more typical following a slight compression of the atrium digitally or by sponge during exposure of the heart (Fig.15).

In cases with a slight constriction of the heart without symptoms, the atrial pressure curve was relatively typical and its amplitude was much larger than the normal one, although the mean atrial pressure was almost normal.

With the more highly constricted atrium, the curve was more typical compared to its mean value.

Furthermore, in our clinical case of mitral steno-insufficiency with a greatly dilated left atrium, typical regurgitant wave was not obtained notwithstanding a strong regurgitant jet which was confirmed when the commissurotomy was perfo-rmed (Fig. 16).

These facts illustrate that the atrial pressure curves are affected strongly by the condition of the atrium, e. g. its distensibility, tone, volume, etc..

The configuration of the atrial curve is affected undoubtedly by various factors, namely, venous filling pressure, right auricular distensibility, vigor of right auricular

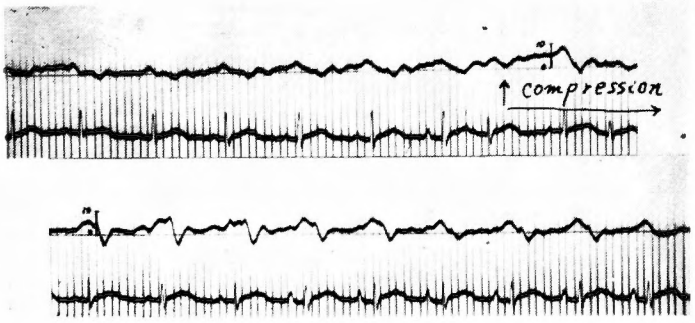

Fig. 15

The pressure tracing from the right atrium before and after a sligt compression of the atrium with a sponge.

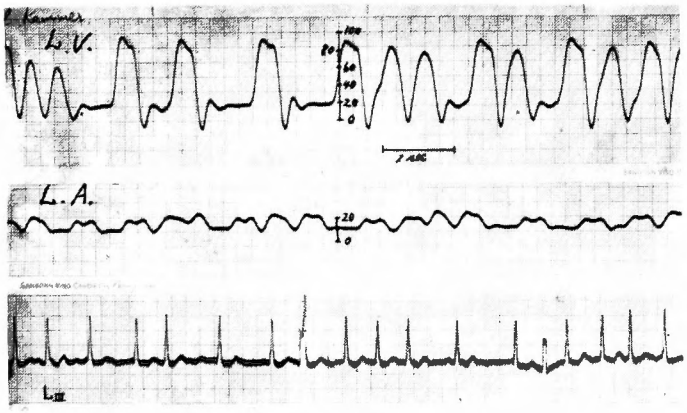

Fig. 16

The pressure tracing from a patient (25 years of age, female), with mitral steno-insuffciciency.

systole, auriculoventricular resistance, tricuspid valvular lesion and right ventricular status, as described by Lin & Anache (1956).

It is likely to be a consequence of the instability of many factors that various forms are obtained from the right atrium in normal dogs. The condition of the atrium itself should be considered for the estimation of the pulmonary capillary and right or left atrial curve in the patient with cardiac valvular disease.

Hansen et al. stated that the form of the curve of the atrium must largely depend on factors other than the contraction of the auricle, since similar curves were obtained even when auricular fibrillation was present (1952).

Wilson et al. claimed that the M or W configuration of the right atrial pressure tracing is caused by two sudden falls in pressure. The first is the result of rapid atrial emptying and the second is due to the right ventricular contraction.

Maekawa emphasizes that the reduction of this suction action, which is caused by the ventricular contraction and is shown by this suction wave, causes a backward venous congestion in patients with a decompensative heart failure (1947). This concept is called "The modified backward failure theory of Maekawa".

Takasaki, with the purpose of confirming this concept, tried to investigate this suction action or the suction volume by observing the curves which were obtained with their esophagocardiograph. The pressure curve in the atrium seems to be more useful for the estimation of such a suction action than the esophagocardiogram. However, sucting action and volume may erroneously be estimated from the configuration of pressure curve alone. In fact, this suction wave is observed conspicuously and has been considered to be characteristic of constrictive pericarditis, although peripheral venous congestion is present to a high degree in this disorder.

THE CURVE FROM THE RIGHT VENTRICLE

The curve from the right ventricle was most essential in this study, since that has been considered to be most characteristic of this disorder.

Previously, some authors considered that this characteristic pattern was caused by a low frequency recording system, or the specific suction action of ventricle.

Presently, this characteristic pattern, namely an early diastolic dip and a high diastolic plateau, has been considered to be the consequence of the ventricle, with a limited filling capacity and with an increased resistance to filling by the highly elastic pericardium, being filled maximally early in diastole from the atrium with a high mean pressure.

Modifying this concept, it seems quite reasonable that a similar characteristic pattern is obtained in myocardial fibrosis, constrictive endocarditis, pericardial effusion and in some cases of general heart failure, e. g., mitral steno-insufficiency which was experienced in our clinic (Fig. 16).

HANSEN et al. considered that if the myocardium were relatively normal the early diastolic dip reaches the zero line since the ventricle is emptied completely as in normal cases or at least almost so, and so that the degree of myocardial insufficiency can be estimated from the appearance of certain ventricular curves.

MAEKAWA stressed that even if the residual blood volume in a ventricle is gross, the intraventricular pressure falls to almost the intrathoracic pressure level in diastole.

A case in which the right coronary artery was ligated proved his opinion immediately after the ligation.

If the residual blood volume is not extremely gross, and the relaxation of the ventricle in diastole is sufficiently rapid, the early diastolic dip will almost reach the zero line.

If myocardial insufficiency is always accompanied with an abnormally slow relaxation of the ventricle, the discussion of HANSEN et al. may be accepted.

CONSIDERATION OF THE PROBLEM AS TO WHY THE SYMPTOMS OF LEFT HEART FAILURE ARE NOT SO EASILY PRODUCED BY THE CONSTRICTION OF THE HEART IN ITS ENTIRETY OR JUST ITS LEFT SIDE.

ISAACS et al. succeeded experimentally in producing the symptoms with such a constriction. HOLMAN in 1952, and later PARSON & HOLMAN in 1955 reported results similar to this study.

PARSON & HOLMAN, in producing their experimental constriction, removed the pericardium on the side opposite to the pericardial pocket into which they infused an irritant fluid.

Polyvinylsponge used by the author was not as irritative as the cast used by ISAACS et al., which was made of vinyl acetate and vinyl cholorid in acetone. Therefore, sponges coated with irritative substance were used in some cases.

The methods used by each author in constricting the heart were different. However, the results similar to PARSON et al. were also obtained in this study.

The author has considered the following. This fact may be the result of a mechanism of automatic control of the output of both ventricles which works by the inflation of the ventriclular septum toward the right ventricular cavity and other factors yet unknown.

"The study of role of the pericardium in regulation of cardiovascular hemodynamics" reported in 1955 by BERGLUND et al. proved this consideration to be reliable.

The fact that constriction of the right side alone did not so easily produce the symptoms as compared to constriction of the whole heart is also reasonable.

Furthermore, the difference between the hydrostatic pressure and oncotic pressure in pulmonary tissue is larger than in the other peripheral tissues as HARVEY et al. described. The pulmonary lymph fluid flows into the systemic veins, and the pulmonary lymph flow is affected by the systemic venous pressure level, namely the degree of the right heart failure.

Owing to many such factors, the symptoms of pulmonary congestion are considered to be difficult to produce by constriction of the left side of the heart or the whole heart.

PHONOCARDIOGRAM

DETERLING & HAMPHREYS reported that systolic murmurs were audible in 9 cases and diastolic murmurs in 2 cases among 25 patients with constrictive pericarditis (1955).

MOUNSEY reported that an added sound in early diastole was recorded in phonocardiograms is 18 out 22 patients with constrictive pericarditis.

By other many authors, it has been reported that diastolic murmurs were audible in almost half of the patients with constrictive pericarditis.

The results in this study support the concept of HANSEN etal. (1951), McKUSICK (1952) and MOUNSEY (1955), that the early diastolic sound in constrictive pericarditis is the result of an abrupt halting of the rapid ventricular filling by the sickened pericardium and is probably a water hammer phenomenon.

The early diastolic sound coincided with the nadir of the early diastolic dip as reports of McKusic (1952) and MOUNSEY (1955).

Systolic sounds of higher frequencies were recorded in some cases. The mechanism of this sound has not been discussed so far as the author knows. It may be considered that this sound is produced by vibration of the ventriclular wall or the outflow portion highly norrowed by the highly sickened pericardial scar.

The early diastolic sound, moreover with the early diastolic dip, may be the collateral sign in diagnosis of constrictive pericarditis.

CONSIDERATION OF THE SURGICAL TREATMENT OF CONSTRICTIVE PERICARDITIS

This study was performed with the use of 142 mongrel dogs with collaborators who each had some other objective in the study.

The author wants to discuss the problem of surgical treatment in this disorder with a brief historical review, although pericardiectomy was not directly performed in this study.

Classically, SCHMIEDEN states that complete liberation of the left ventricle is the most important part of the procedure and that in most cases this is the only surgical measure that is necessary (1926).

CHURCHILL stresses the importance of freeing the right auriculoventricular groove (1936).

BURWELL & BLALOCK believe that major emphasis should be placed on decorticating the right ventricle but that both ventricles must be freed (1938).

BLALOCK & BURWELL state that most patients with constrictive pericarditis have remarkable little dyspnea or edema of the lungs in comparison with the marked evidence of congestion in the systemic circulation, and that most of the signs and symptoms are attributable to a back pressure from the right side of the heart. They emphasize that liberation of the right ventricle is most important (1941).

HARRINGTON believes that it is advisable separate as much of the pericardial scar as possible from the ventricle, the right auricle and orifice of the inferior vena cava, and it is of particular importance to separate the attachment of the right ventricle and equally the apex of the heart to the diaphragm (1944).

SELLOR states that excision should aim primarily and possibly only at freeing the ventricles, though for anatomical reasons even this is rarely achieved. He considers, in common with CHURCHILL, BLALOCK & BURWELL and the others, that the removal of the scar from the auricle and the caval region is rarely necessary and is highly hazardous (1946).

DECKER argues, in contradiction to these opinions, that only the left ventricle requires decortication and that only a limited amount of pericardium should be removed as it is a not unnecessary organ (1940).

WHITE et al. support the concept of the importance of the involvement of the left ventricle (1948).

HOLMAN et al. emphasize their two principles, first, the necessity of adequately exposing the entire heart and its great vessels, so that the surgeon may have ready access to every strategic area requiring liberation, and second, the imperative need of a wide removal of the diseased pericardium, including, most particularly, the decortication of the right and inferior borders of the superior and inferior vena cava (1949).

BLALOCK states that the logical conclusion should appear to be that both the right and left sides of the heart should be decorticated (1952).

CONDORELLI et al. state in their monograph that constrictive pericarditis mainly affects the right heart and through it the venous circulation, and various diagnostic techniques furnish the surgeon with important data as to where to operate (1954).

VERNEJOUL stated at Tokyo that, most are agreed that the decortication from the constricted heart should be performed first to the left ventricle in order to avoid the development of functional insufficiency of the tricuspid valve (1955).

PARSON et al. concluded experimentally that decortication must include both ventricles, the venae cavae, and the auriculoventricular grooves if these structures are found to be invested by a constricting pericardium (1955).

In this country, OZAWA, KIMOTO and SAKAKIBARA et al., in common, are agreed that it is advisable to separate as much of the pericardial scar as possible from the both sides of the heart. The wide discrepancy is likely to be the consequence of the differences in various factors of the cases treated by each author.

Considerating the results of this study, it is likely that the liberation of one side alone can liberate the other side of the heart to a some degree, though excessive dilation of the liberated ventricular wall with myocardial atrophy may occur.

Undoubtedly, if any structure of the heart is found to be invested by the constricting pericardium and the constriction is found to affect the cardiovascular function, that structure should be liberated from the constriction.

If both sides of the heart are found to be constricted and the presence of myocardial atrophy is excludable at all, it is advisable, as a matter of course, to separate as much of the pericardial scar as possible from both sides of the heart.

The author concludes confidently that left heart failure is not so easily produced by constriction of the left side or the whole heart, as the result of PARSON et al. and many other clinical papers show.

Therefore, if pulmonary congestion is in addition to the peripheral congestion, present, and a high degree of myocardial atrophy is excluded, the left side of the heart, particularly, should be liberated sufficiently.

If the atrophic myocardium is invested by fibrous tissue or by pericardial scars, the characteristic pattern in the ventricular pressure tracing, namely a typical early diastolic dip may be obtained even in cases with myocardial atrophy.

Therefore, the appearance of certain ventricular curves may not always be indicative for an estimation of the condition of myocardium, in contradiction to the opinion of HANSEN et al. Some cases of constrictive pericarditis with typical ventricular curve should not be treated by total pericardiectomy. The reason is that the fibrous tissue or pericardial scars are highly useful in preventing an excessive dilatation of the atrophic ventricular wall.

SUMMARY AND CONCLUSION

1) In the surviving cases with constriction of the right side of the heart or the whole heart, the symptoms of right heart failure alone developed typically. In these cases the early diastolic dip in ventricular curves and M or W configuration with a high mean value in the right atrial curves were observed.

2) The constriction of the left side alone of the heart could not easily produce the symptoms of left heart failure. In the surviving cases, the right ventricular and atrial curves were quite normal with a slight elevation of the pulmonary capillary and artery pressure.

3) In the cases of myocardial fibrosis with atrophy, produced by ligation of the right coronary artery, the configuration of the right ventricular pressure curve was observed as well as the constrictive pericarditis. It is, therefore, very erroneous to estimate the grade of myocardial insufficiency by the appearance of a certain ventricular curve.

4) In some cases in which the symptoms of right heart failure were present,

the right ventricular pressure suddenly doubled or tripled for a while during the catheterization, and then gradually droped to almost the same value as before the elevation. Anoxia and hypercapnea were excluded from the causes of this phenomen. This phenomen would appear to be the result of nervous reflexes from the ventricular wall to the pulmonary vessels.

5) The early diastolic sound coincided with the nadir of the typical diastolic dip. In some cases with relatively slight symptoms, a high frequency systolic sound was recorded with no typical early diastolic dip and diastolic sound.

6) If constriction of both sides of the heart is found to affect the cardiovascular function, and myocardial atrophy is excluded, pericardiectomy should be performed sufficiently from both sides of the heart.

7) Even in cases with myocardial atrophy, the early diastolic dip was obtained. Therefore, these cases should not be treated by complete, but partial pericardiectomy to prevent excessive dilation of the ventricular wall.

8) The problems as to why the symptoms do not develop more easily by the constriction of the left side ot the heart rather than by that of the right side were discussed.

In cases which clearly show the symptoms of left heart failure, pericardiectomy should be aimed especially at the left side of the heart.

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和文抄録

収縮性心膜炎に関する実験的研究，特にその右心内圧曲線に就いて

京都大学医学部外科学教室第2講座（指導：青柳安誠教授）
助手 九間外喜雄

収縮性心膜炎の外科的処置に関しては，従来決定的な方針がなく，又此の問題に関して，心筋障害の程度は極めて重要な因子とされて来た．之等の問題を解明すべく，著者が作製した電気血圧計を使用して，右心カシーター法による右心内圧曲線を中心に，実験的研究を行ない，次の結論を得た．

1. 右心及び全心の収縮性心膜炎例に於いては，右心不全の症状のみを呈し，右心内圧曲線は，特徴的な右室拡張初期降下，之に続く平坦部，及びM或はW型の右房圧曲線が観察された．

2. 左心収縮例に於いては，左心不全の症状は極めて起り難く，従つて，肺動脈圧，肺毛細管圧が軽度に上昇するのみで，右心内圧曲線は略々正常であつた．

3. 心筋萎縮を伴つた心筋線維症の例に於いても，収縮性心膜炎例と略々同様の右心内圧曲線が観察された．従つて，心室内圧曲線によつて，心筋障害の程度を，必ずしも推定することは出来ない．

4. 右心不全症状を呈する例に於いて，カシーター検査中，何等誘因と思われるものがなく，右心内圧が急激に，2乃至3倍に上昇し，暫時の後以前の値に下降する現象が，時おり観察され，此の現象は，心室壁から肺血管への亢進した神経反射の結果によることを推断した．

5. 第3心音は，心室拡張初期降下の最低部に略々時間的に一致し，その発生機転は，血液の槌様作用によることを確認し得た．

6. 右心，左心共に収縮されており，それが心臓循環機能を障害していることが証明され，且高度の心筋障害が除外された場合は，心膜切除は左右心共に充分行われるべきである．

7. 心筋萎縮を伴う例に於いても，典型的な曲線を示すことがあり，此のような例では，心室の過大拡張を防ぐ意味で，適当な部分的心膜切除が望ましい．

8. 軽度の右心不全を示し，且明らかに左心不全の症状を呈する如き例では，極めて高度の左心収縮を考えねばならず，心膜切除は，左心に重点をおいて行われるべきである．